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I, JONNE YABSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2002950078 for a patent by KEVIN STEPHEN DAVIES as filed on 10 July 2002.

WITNESS my hand this
Seventeenth day of June 2003

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PROVISIONAL SPECIFICATION FOR THE INVENTION ENTITLED

"A SAFETY SYSTEM"

The present invention will be described in the following statement:

TITLE
"A SAFETY SYSTEM"

The present invention relates to a safety system, in particular a system for use with machinery having moving parts, such as press brakes, to detect the presence of an obstruction in the path of the moving part.

In the past, various mechanisms have been used to prevent the operators of industrial machinery, such as press brakes, from placing their hands beneath the moving tool during operation. Such action by the operator obviously has the potential to cause serious injury to the operator, given the force applied by the tool and the speed at which it can move.

One such safety mechanism involves the use of physical guards that are placed between the operator and the tool. The use of physical safety guards however can obstruct the view of the operator during use and impede access to the work making it difficult for the operator to perform their job in the most efficient manner. Also, physical tethers have been used to keep the operator at a safe distance from the moving tool during operation. Tethers have been employed in the form of a double handed start switch at a safe distance from the tool to ensure that the operator does not have a free hand to place near the tool during operation. The use of tethers however also makes holding and manipulation of the work difficult and therefore decreases the efficiency with which the operator can work.

Various arrangements have also been used where a number of light beams are used to create a light curtain which bounds an area around the path of the moving tool which is deemed to be hazardous. The light beams are projected onto detectors which are able to sense when the beam is broken and trigger either a halt or slow down of the

movement of the tool. These arrangements of individual light beams also have disadvantages in that the operator is kept away from the work area. It is generally necessary also to reset the position of the light curtains between production batches. Also, they define only one area around the tool which, if obstructed by any object, whether part of the operator or not, will deactivate the machinery. Further the use of individual light beams also results in small gaps in the light curtain, into which small objects such as fingers can be placed without triggering deactivation of the machine.

A further method of providing safety protection is with the use of one or more light beams projected along the leading edge of the tool. The light beams are arranged to move with the tool and slow or stop the tool if an obstruction breaks the beam. In such arrangements the beam must be deactivated as the tool approaches the work and the light beam must be set at a sufficient distance from the tool to stop the tool in time. The minimum permissable distance of the beam from the tool is therefore dependent on the maximum speed of movement of the tool. In some cases, multiple light beams may be used at varying distances from the tool.

Known problems with these types of arrangements include the need to re-align the light beams when tools are changed and the possibility that an operator may move their hand under the tool just as the beams are deactivated. Also, as with light curtains, all parts of the work, such as bent up stands when bending a box in a press brake, must be kept clear of the beams as operator confirmation is required every time a new obstruction is encountered. At present, the only known arrangement in which the blade may travel fully to the anvil without interruption is when a flat piece of metal is on the anvil.

The present invention attempts to overcome at least in part some of the aforementioned disadvantages of previous safety systems used for detecting the presence of obstructions in hazardous areas around machines having moving parts.

In accordance with one aspect of the present invention there is provided a safety system for use with a machine having a moving tool arranged to move through a known path of movement, the safety system being arranged to detect the presence of an obstruction in a region around a portion of said path deemed to be hazardous, the safety system comprising:

a light emitting means arranged to emit light generally parallel to the path of movement of the tool such that said region is illuminated;

a light receiving means arranged to receive light from the light emitting means which has passed through said region; and

a processing and control means arranged to receive information from the light receiving means and determine whether an obstruction exists in said region by the presence of one or more shadow regions cast on the light receiving means by the obstruction and to control movement of the tool dependent on the presence of obstructions in said region.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1a is a view of a light emitting means and lens arrangement for illuminating a region under the tool, in accordance with the present invention;

Figure 1b is a view of an alternative embodiment of a light emitting means and lens arrangement for illuminating the region under the tool;

Figure 2a is a view of a light receiving means and lens arrangement for receiving light from the light transmitting means of Figure 1a;

Figure 2b is a view of a light receiving means and lens arrangement for receiving light from the light transmitting means of Figure 1b;

Figure 3 is a perspective view of a CCD used as the light receiving means;

Figure 4 is a perspective view of a press brake with a region around the tool edge illuminated in accordance with the present invention;

Figure 5 is a cross sectional view of the illuminated region created by the light emitting means showing a shadow mask used for checking purposes; and

Figure 6 is a view of a shadow map 54 created by the safety system during operation of the press brake of Figure 4.

Referring to the Figures, there is shown a safety system for use with machinery having moving parts to detect the presence of an obstruction in the path of the moving part. In the embodiment shown, the safety system is employed on a press brake comprising a tool 12 arranged to move relative to an anvil 14 and to strike work placed on the anvil 14. The safety system includes a light emitting means 16 and a light receiving means 18. The light emitting means 16 is arranged to illuminate a region 20 around a portion of the path of movement of the tool 12 in order to detect obstructions in said region 20.

Figure 1a shows an arrangement in which a laser diode 22 is used to create a large area parallel light beam 24. In the arrangement shown in Figure 1a, the laser diode 22 is used to illuminate a spherical ball 25. The spherical ball 25 concentrates the laser beam onto a point 26. The point source of light may be further refined by passing it through a pin hole (not shown), Past the point 26, the laser light beam is corrected by

the use of a transmitting end concave lens 30 and a first transmitting end convex lens 32. The light beam is then formed into the parallel beam 24 by a second transmitting end convex lens 34. It will be appreciated that while an arrangement using the spherical ball 24, transmitting end concave lens 30 and first and second transmitting end convex lenses 32 and 34 has been used to create the parallel light beam 24 in this embodiment, other arrangements would be possible to generate the parallel light beam 24.

Figure 1b shows an alternative arrangement in which the laser diode 22 is used to create the large area parallel light beam 24. In this arrangement, a transmitting end aspheric or achromatic lens 35 is used in place of the transmitting end concave lens 30 and first and second transmitting end convex lenses 32 and 34. Also a transmitting end mirror 32 is used to allow an increase in focal length without significantly increasing the length of the light emitting means arrangement which allows the spherical ball 25 to be removed.

Figure 2a shows an arrangement used for focussing the parallel light beam 24 onto the light receiving means 18. The arrangement of lenses used is the reverse of that shown in Figure 1a, in that the light beam 24 is passed through first and second receiving end convex lenses 36 and 38 and a receiving end concave lens 40 in order to focus the beam 24 onto the light receiving means 18.

Figure 2b shows an alternative arrangement for focussing the parallel light beam 24. The arrangement is the reverse of the transmitting end, using a receiving end achromatic or aspheric lens 39 and a receiving end mirror 41.

The light receiving means 18 comprises a pinhole aperture 42 in a screen 44 and a charge coupled device (CCD) 46. Preferably, the receiving end lens arrangement is such that the focal length is adjusted to be slightly divergent. In this way, a higher intensity of illumination on one side of the CCD 46 can be interpreted as a misalignment which can then be corrected. Also, the receiving end arrangement is preferably such that only a portion of the surface of the CCD 46 is illuminated as shown in Figure 3. This permits the device to output only part of each line and only part of each frame, thus resulting in higher frame rates than would normally be expected from a standard CCD.

As shown in Figure 4, the light emitting means 16 is mounted at one end of the tool 12 of the press brake such that the parallel light beam 24 illuminates a region 20 around the path of movement of the tool 12 which includes the forward edge 48 of the tool 12. The light receiving means 18 is mounted at the opposite end of the tool 18 to receive the light beam 24. If an obstruction 50, such as the hand of the operator, enters the region 20, a corresponding shadow 52 will be cast on the CCD 46. The light emitting means 16 and light receiving means 18 are mounted to be stationary relative to the tool 12.

The safety system also includes a processing and control means (not shown) connected such that the processing and control means receives information from the light receiving means 18 and processes this information and controls operation of the press brake. The processing and control means may be in the form of a software program residing on a computer which receives input from the output of the light receiving means 18. The processing and control means captures the images received by the CCD 46 and processes the images to search for any unknown shadows.

A total picture made up of the image information received by the light receiving means 18 as the tool 12 moves through its path of movement is created and stored in a memory means by the processing and control means. This total picture will be referred to as a shadow map. A shadow map 54 is shown in Figure 1 in which no shadows other than those of the tool 12 and anvil 14 are detected. Such a shadow map 54 would be created on a first pass of the tool.

The processing and control means can store in the memory means a number of known safe shadow maps. The known safe shadow maps being shadow maps 54 where no obstruction is detected which would require stopping or slowing of the press brake. For example, the shadow map 54 in which the only shadow cast is that of the forward edge of the tool 12 and the anvil would be a known safe shadow map 54.

In use, if an obstruction is placed in the path of the light beam 24, a shadow 52 is cast on the CCD 46. The processing means recognises the presence of an unknown shadowed area in the shadow map 54 and halts or slows the movement of the tool until either the shadow disappears by removal of the obstruction or the operator confirms that operation of the press brake is safe to continue by operation of a suitable input means provided to notify this to the processing and control means. Further the processing and control means could allow the tool 12 to descend to a point adjacent the obstruction before stopping in order to assist the operator to identify the location of the obstruction which has triggered the deactivation of the press brake.

In the case where the obstruction detected by the safety system is one deemed to be safe to continue operation, such as the edge of work which has previously been bent up, the processing and control means stores that shadow map as a known safe shadow map. Therefore, when this work is repeated, the processing and control means

automatically recognises the obstruction as being non-hazardous and allows continued operation of the press brake.

The processing and control means may still however determine that an obstruction is hazardous even if the obstruction has previously been detected and the operator has confirmed it is safe to proceed. For example, if the processing and control means detects a known shadow adjacent an edge of the illuminated region, and the known shadow is determined to be of a sufficient size that it could be hiding a hazardous obstruction, then the processing and control means would need to slow or stop movement of the tool 12.

To maintain safety requirements, the known safe shadow maps are discarded by the processing and control means if they are not re-detected within a specified time period.

The processing and control means also includes means to reduce the possibility of false triggering. The processing and control means provides for shadow expansion, whereby the shadow is expanded by a sufficient number of pixels to allow for vibration or other inaccuracies. Also, shadows created while the tool 12 is stopping are ignored due to the possibility of the high deceleration deflecting the light emitting and receiving means 16 and 18. Further, the processing and control means ignores the action of the press brake back gauge. The shape and possible positions of the back gauge are pre-configured into the safety system when the safety system is first commissioned.

The safety system would preferably be provided with a shadow mask 56, as shown in Figure 5, placed in front of the light emitting means 16 used for checking that the safety system is receiving the light beam 24 correctly. The shadow mask 56

comprises a shape known to the processing and control means, such as a cross 58. The processing and control means then checks for the presence of the shadow mask 56 shape and triggers deactivation of the press brake should the shadow mask 56 not be detected.

It may be required due to some safety standards for the light emitting device to be pulsed such that the light emitting means 16 is turned off or dimmed between each frame being acquired. The light emitting means 16 would preferably be turned on for the minimum time period required to activate the CCD, thus assisting the processing and control means via a strobing effect. The processing and control means can use the off or dimmed period to ensure that ambient light does not falsely illuminate the light receiving means 18.

The safety system is provided with an output device, such as a screen or computer monitor which displays the images cast on the CCD 46 and therefore assists the operator in identifying the obstructions detected.

The safety system could also include the use of a quartz deflection device in front of the light receiving means 18 to correct for vibration and could also employ off-axis parabolic reflectors within the light emitting and receiving means 16 and 18 arrangements to remove the need for lensing and increase the sensing area. Also, the processing and control means could analyse the bending of the work in order to reduce the risk of finger entrapment between the work and the tool 12.

Also the safety system may include vernier adjustments for the direction of the light emitting and/or receiving means 16 and 18 and either adjust the direction automatically or show lights on the device to indicate in which direction the device is out of alignment.

Modifications and variations as would be apparent to a skilled addressee are deemed to be within the scope of the present invention. For example, while the light beam 24 is described as a large area parallel light beam, it would be possible to use a matrix of focussed light emitting means and a matrix of discrete sensors. A sweet spot pin photodiode could be used with a matrix of light emitting means being pulsed so as to produce a picture. Alternatively, a scanning parallel ray laser could be used in place of the matrix of light emitting means. In this method, the lights in the matrix could be pulsed one after the other in a scanning arrangement or the laser scanned so that the pin photodiode turns on when a parallel ray of light is received from the matrix and stays off when an obstruction casts a shadow. Further, a row of sweet spot pin photodiodes could be used and places behind an optical slit. Many wide beam lasers could then be flashed sequentially so as to produce a picture in a similar fashion to that described above. Also, the light emitting means 16 and light receiving means 18 could be mounted to be stationary with respect to the anvil 14 rather than the tool 12 and alternative devices could be used for the components of the light emitting means 16, light receiving means 18 and associated optical equipment.

DATED THIS 10TH DAY OF JULY 2002.

Kevin Lord

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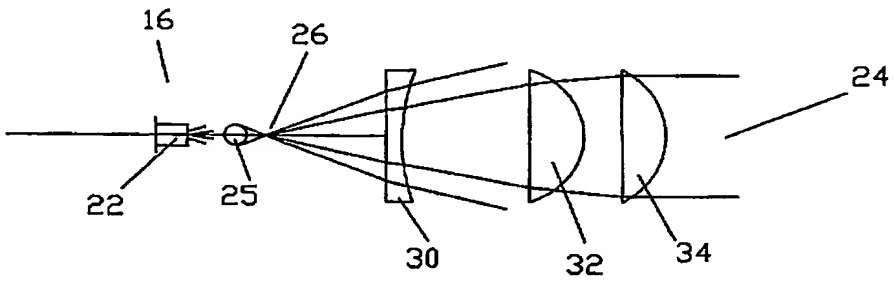

Fig 1a

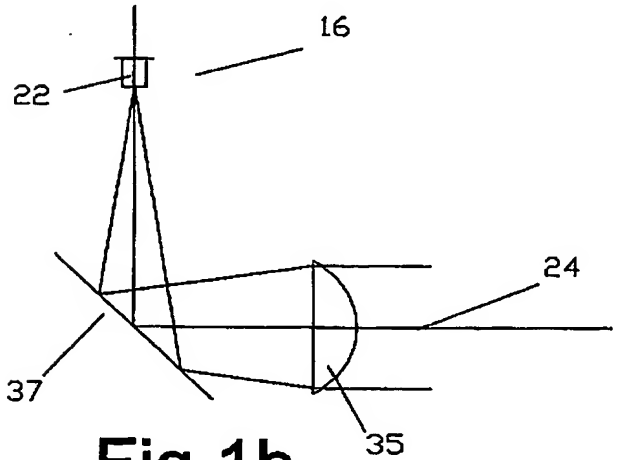

Fig 1b

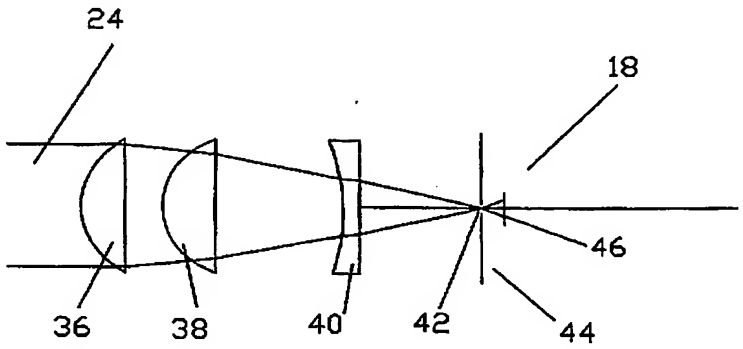

Fig 2a

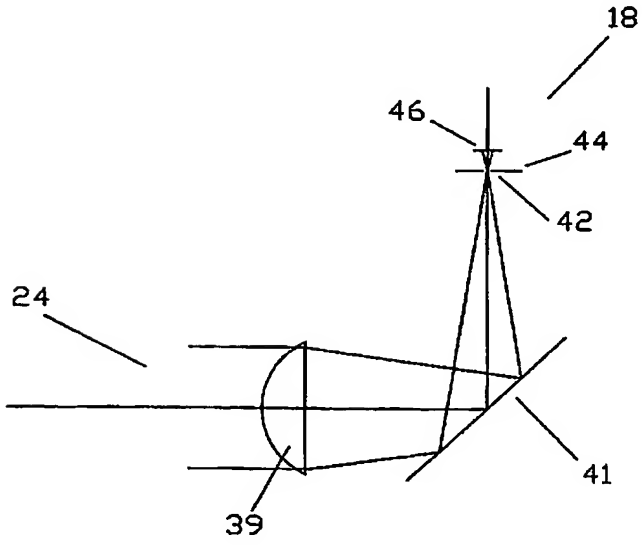

Fig 2b

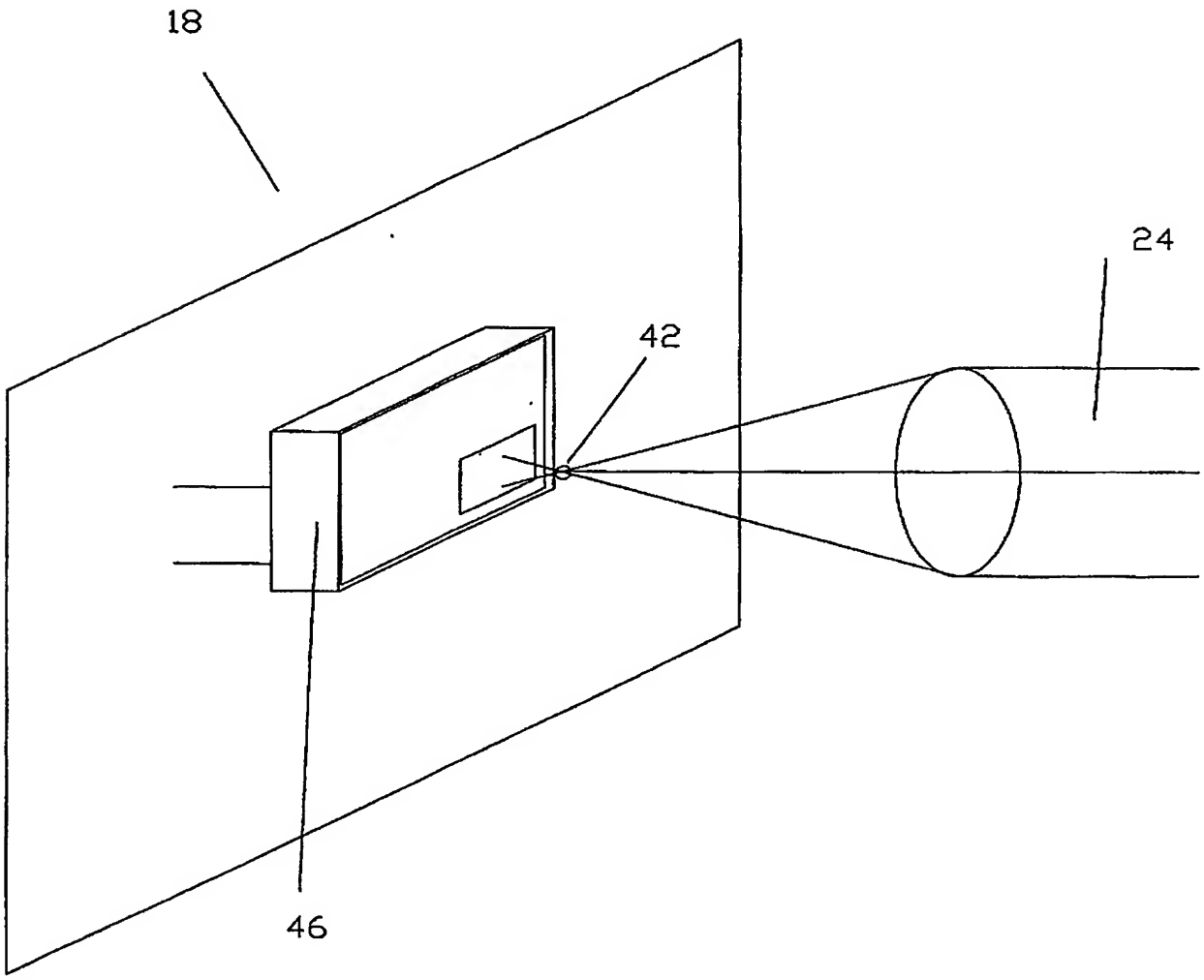

Fig 3

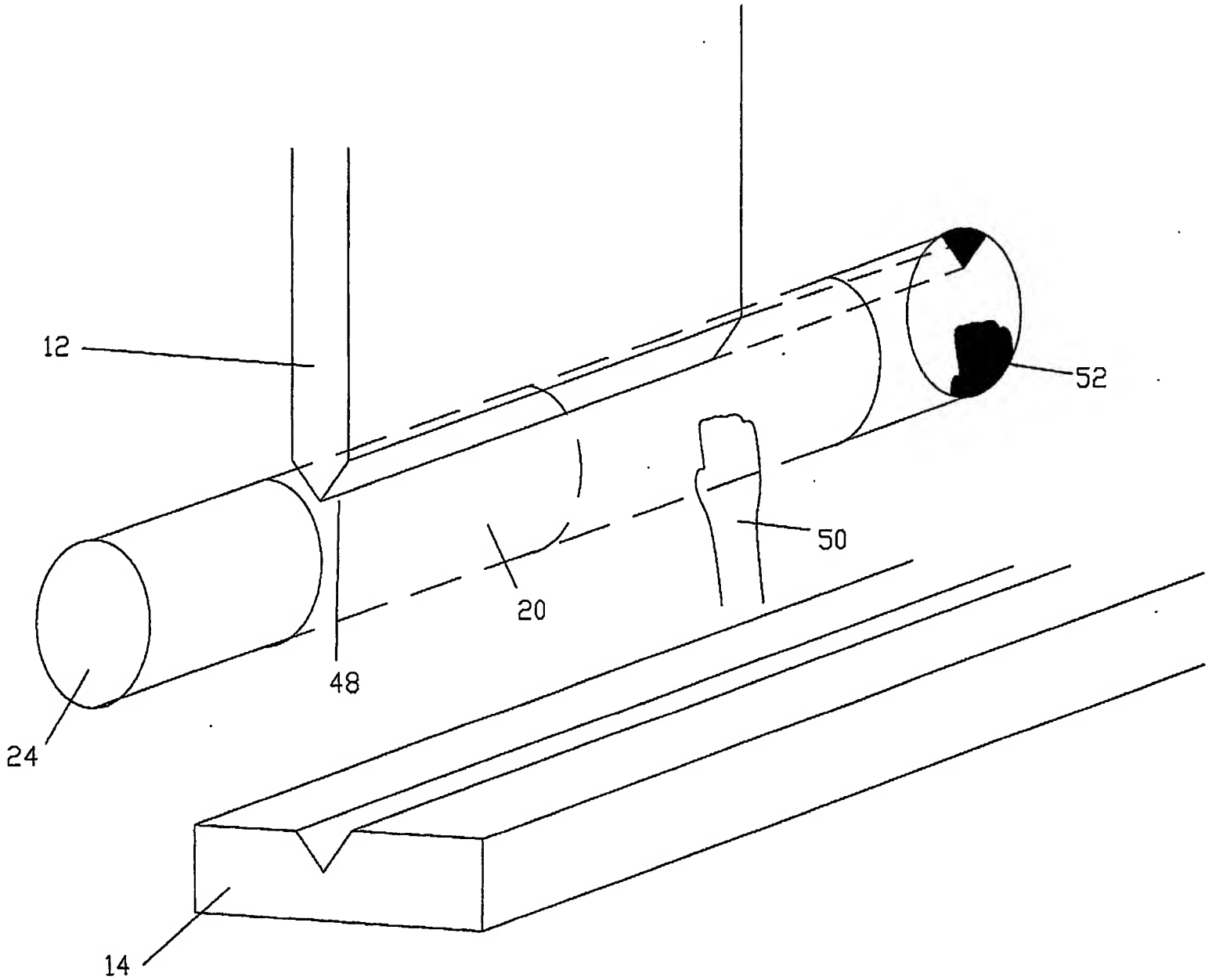

Fig 4

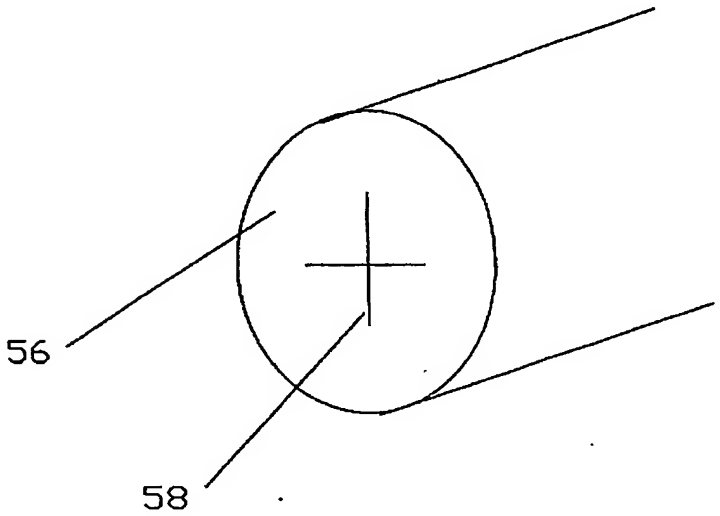

Fig 5

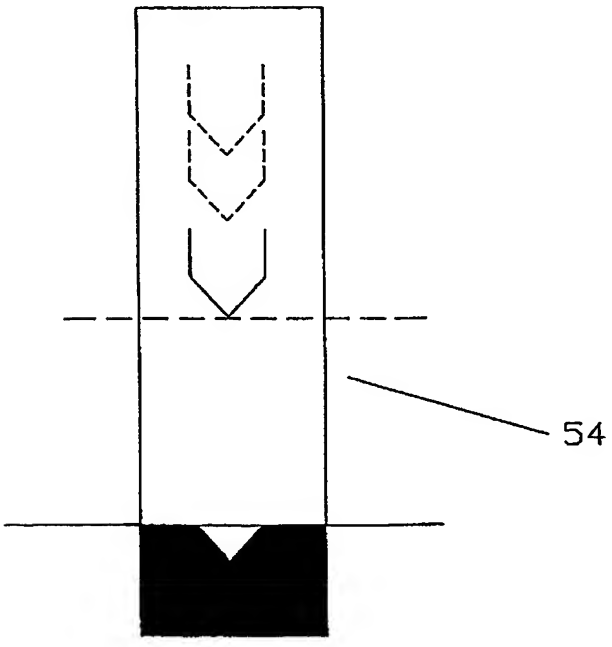

Fig 6